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ABSTRACT

This study investigated the research construct of encoding specificity using an applied research orientation. Encoding specificity considers the effects on memory of the interactive relationship among encoding, the stored memory trace, and external retrieval cues. Subjects were 273 undergraduate students enrolled in the College of Engineering at The Pennsylvania State University. Typical classroom presentation and testing methods were used to investigate the encoding specificity hypothesis. Two types of instructional slide presentations were given, one visualized and one verbalized (with an audiotape recording). Three types of testing measures were used to test factual learning, each providing different types of external retrieval cues: free recall, verbally cued-recall, and visually cued-recall. A complex relationship existed between type of instruction and type of external cue provided during testing, essentially supporting the encoding specificity hypothesis. Fourteen references are listed. (Author/LMM)

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The Effects of Recall Cue and Cognitive Trace Compatibility When Learning from Mediated Instruction:

An Applied View of Encoding Specificity

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ABSTRACT

The present study investigated the research construct of encoding specificity using an applied research orientation. Encoding specificity considers the effects on memory of the interactive relationship among encoding, the stored memory trace, and external retrieval cues. The present experiment used typical classroom presentation methods and testing methods to investigate the encoding specificity hypothesis. Two types of instructional presentations were given, one visualized and one verbalized. Three types of testing measures were used to test factual learning, each providing different types of external retrieval cues; free recall; verbally cued-recall, and visually cued-recall. A complex relationship existed between type of instruction and type of external cue provided during testing, essentially supporting the encoding specificity hypothesis.

Problem and Rationale

The psychological research construct of encoding specificity addresses an important orientation for educational technologists involved with research on learning and instructional development activities. In the encoding specificity orientation, the ability to recall learned information is a direct function of the relationship which exists among encoding [information input/learning], the stored memory trace [cognitive information], and the external retrieval cue. In this respect, encoding specificity research concludes that it is possible for information to be available in the cognitive structure, and therefore to have been learned; however, for retrieval purposes this information may be inaccessible because the appropriate external retrieval cues may not be available in the testing environment.

The importance of the encoding specificity construct for educational technologists is revealed by the fact that a number of research studies have found that significant interactions exist among encoding, memory trace, and external retrieval cues. The practical significance inherent in the encoding specificity construct implies that if a mismatch exists between how instructional content was originally presented to students and how it was subsequently evaluated - in terms of having the appropriate retrieval cues available in the evaluation mode - students will not be able to utilize fully information previously acquired.

Although a number of empirical studies have been conducted on the encoding specificity construct, little applied research is currently available. Most of this research has focused on types of learning and experimental conditions far removed from what might be expected to be found in a typical classroom environment. While these research findings are valuable, they make generalization to specific classroom instructional environments difficult. The present study purports to address this problem by using typical classroom instructional materials, academic content, and environment, within the context of an encoding specificity study. The majority of past research in the encoding specificity area has used various forms of paired-associate learning tasks presented to individual subjects, representing essentially a laboratory situation, (Tulving, 1979).

The learning conditions in the present study use a slide-tape instructional presentation, typical of an audiovisual segment during a class session. The experimental conditions were conducted in a classroom setting with groups of 40 subjects. Of course the subjects were aware that they were involved in an educational study, but they were told that the content they were to learn was a typical college type of academic content in physiology. Additionally, they were told that the presentation method was a slide-tape audiovisual presentation, similar to what would be seen as part of a class session. They were also told that they would be required to remember information presented in

the audiovisual program, similar to what would be done during an audiovisual classroom segment. While the subjects knew they were involved in an experiment in learning, the present studies' conditions emulated a classroom situation far beyond most of the past research with the encoding specificity construct.

Furthermore, the slide-tape content presents the learner with an instructional program which describes the names of the parts and functions of the human heart. Again this content is typical of what would be found at the college level in a biology class audiovisual segment to complement a lecture. The slide-tape instructional materials employed in the study were an adaptation of the Dwyer (1967, 1978) instructional treatment materials. These materials were used because they closely resemble audiovisual instructional presentations used in the classroom and have been validated in a large number of studies investigating a variety of instructional and learning hypothesis (Dwyer, 1982).

Related Encoding Specificity Research

The crux of the encoding specificity research orientation is involved with the interactive relationship which exists among the encoding phases, the memory trace, retrieval cues, and subsequent effects upon the learner's skill performance. Basic research on encoding specificity, from a psychological research paradigm, suggests that encoding specificity is not a superficial phenomenon, but is rather a psychological principle. Tulving (1979, p. 417) in reviewing the related literature in this area

has concluded that "... over a considerable range of experimental conditions, empirical facts show that remembering of events is determined by the interaction between encoding and retrieval." Similarly, in an early study, Tulving and Osler (1968) found a direct relationship between encoding and retrieval. Using a paired-associate learning paradigm, they had two encoding conditions and two retrieval conditions. The two encoding conditions were; (1) a target word plus cue A, and (2) a target word plus cue B. The two retrieval conditions were; (1) present retrieval cue A, and (2) present retrieval cue B. The experiment resulted in the following strong interaction as revealed by percent of correct recalled target words.

	(Retrieval Cue)	
(Encoding Cue)	A	B
A	62%	29%
B	33%	62%

From these results Tulving and Osler concluded that successful retrieval of information stored in the cognitive structure is contingent upon the appropriate external cue to match the stored memory traces. It should also be noted that this early study represents the typical encoding specificity experimental setting, using paired-associates, administered to individual subjects. This type of highly experimental setting is quite removed from

typical classroom instructional environments. Additionally, note that the retrieval cues are similar, stemming from the encoding contexts, but represent different cues to access different memory traces. This difference in cues should not be interpreted as cue incompatibility, but simply as different cueing types.

In a later experiment by Thomson and Tulving (1970), similar results occurred, indicating a strong significant relationship between encoding and retrieval cue. This experiment used a paired-associate learning task and several types of cue conditions. From their results, Thomson and Tulving (1970, p. 261) concluded that "retrieval of event information can only be effected by retrieval cues corresponding to a part of the total encoding pattern representing the perceptual registration of the occurrence of the event." In this respect the original encoding specificity hypothesis can be interpreted to indicate that retrieval is facilitated if external retrieval cues match a part of what was stored during learning.

The majority of the encoding specificity research has used experimental designs that directly relate to the memory elements of encoding, the memory trace, retrieval cues, and the interaction of these memory elements, (Anderson, Pichart, Goetz, Schallert, Stevens, and Trollip, 1976; Tulving and Watkins, 1975; Moscovitch and Craik, 1976). Results of these experiments generally confirm the encoding specificity hypothesis. However, there is the counter argument that is offered by the levels of processing research orientation. Craik and Lockhart (1972, p.

645) contend that "trace persistence is a function of depth of analysis, with deeper levels of analysis associated with more elaborate, longer lasting, and stronger traces." In line with the levels of processing conclusions, memory research further indicates that orienting tasks which tend to cause deeper more elaborate memory traces do improve recall of learned information, (Hyde and Jenkins, 1969; 1973). Such orienting tasks could be directions to form images, advance organizers, or specific acquired mnemonic strategies. Craik and Tulving (1975) found that free recall and recognition varied considerably, contingent upon the type of orienting tasks, or memory instructions, given prior to learning.

However, while the levels of processing orientation appears viable, in explaining psychological factors related to recall and the recognition of stored information, the levels of processing orientation provides only part of the explanation. Recall and recognition memory are probably effected by orienting tasks altering processing level, but the relationship between the stored memory trace and external retrieval cues is a strong variable determining the success of memory operations. In a series of experiments investigating the levels of processing hypothesis, Fisher and Craik (1977, p. 709) concluded that "... the retention levels associated with a particular type of encoding were not fixed, but depended heavily on the type of retrieval cue used." This conclusion may be interpreted to indicate that external retrieval cues will have a significant

relationship to learned information, in terms of improving or debilitating recall and recognition.

One generalization which may be derived from past research on encoding specificity is that a significant relationship exists among encoding, the stored memory trace, and the external retrieval cue. Additionally, the compatibility of these three memory elements will have significant effects upon the learner's ability to apply stored information during the testing situation. The problem with much of the past research in this area, however, is that learning tasks, learning materials, and presentation methods, employed in the experimental context, are too removed from typical instructional methods and classroom settings. This situation makes it difficult to apply these significant research results to the task of designing appropriate evaluation and testing methods, that match instruction in terms of the basic memory elements of encoding, memory trace, and retrieval cues. The present study attempts to evaluate the encoding specificity orientation within the context of an applied learning situation.

Experimental Design and Procedures

This study employed a 2x3 analysis of variance design utilizing two between-subjects variables. The first between-subjects variable was the type of instruction presented. The two levels of the instructional variable were the visualized mediated instruction (VISU) and the verbally mediated instruction (VERB). The type of content included in each instructional unit

was representative of the kind of academic content typically presented in teaching-learning situations. The instructional unit was designed to instruct learners on the names of the parts and processes of the human heart. The instructional units were presented in the form of slide-tape presentations lasting 22 minutes. Both slide-tape programs used the same pulse synchronized audio tape, so the to-be-learned instructional content in both units was identical. The difference between the VISU and VERB instructional presentation was in the slide portion of the presentations. Both groups saw the same number of slides in the same sequence. The VISU group saw a color illustration slide set with a verbal label identifying the relevant heart part on each slide, and an arrow pointing to the part. Each slide was an artist drawn illustration of a dissected heart, similar to what would be found in a textbook. The VERB group saw a set of verbal label slides, which consisted of a verbal label that named the heart part described on the audio tape. the VERB slide set presented the same verbal labels that appeared on the VISU slide set, but did not contain an artist illustration. The VERB slide set contained verbally mediated instructional content, supported by the audio tape program.

The second between-subjects variable was the type of cueing measure used during testing. This variable serves as the key to the encoding specificity hypothesis in the context of this experiment. Three measures of the cueing variable were employed (free recall, visually cued-recall, verbally cued-recall). These

three measures were designed to test the learners' ability to acquire from the slide-tape instructional programs the names of the parts of the heart and the heart phase names. There were 19 part names and 2 phase names to be learned from the instructional programs, producing a total of 21 possible points on each measure. All three measures tested the same intellectual skill, in this case the factual learning of 21 part and phase names. Both instructional units provided the learner with the same target information to accomplish the specified learning task. However, the difference in each of the measures was in the type of external retrieval cue provided to the learner during testing. The measures represent different cues designed to assess the same encoded target information, the 21 part and phase names assumed to be stored as a function of interacting with the heart slide-tape instructional programs. Both the visually cued-recall measure and verbally cued-recall measure were derived from the original instructional program content, so they were compatible, but represent different cues to assess the stored memory traces.

The free recall measure required the subject to list the 19 parts of the heart and the 2 heart phase names from memory, in any order. The visually cued-recall measure required the subject to write down the correct part name when he saw that part identified by an arrow on an illustration slide. To accomplish this, subjects saw the illustration slides of the heart, describing the parts and phases, with the <u>verbal labels removed</u>.

Each slide had an arrow, however, pointing to the part in question, and subjects were instructed to write down the part name. The slides used were from the VISU instructional program and were the slides naming the parts and phases, however, the slides were altered by removing the verbal labels.

The verbally cued-recall measure provided the subject with a verbal cue of the part name or phase name in question. To accomplish this subjects saw a set of verbal cue slides. This set of slides consisted of 21 slides, each containing a verbal cue relevant to a particular part or name. The verbal cue on each slide consisted of the first three letters of the part name the subject was to recall. For example, the cue for myocardium, was MYO. For heart part names that distinguished between arteries, veins or valves, (i.e., Pulmonary Artery vs. Pulmonary Valve), the cue AR, VE, or VA was given next to the three letter cue. Additionally, for a part that was distinguished as Right or Left, the cue R or L was added to the three letter cue. Subjects were instructed to write down the complete name of the part or phase when they saw the cue slide.

A total of 273 undergraduate level students enrolled in the College of Engineering at The Pennsylvania State University constituted the population for this study. All subjects took a pretest on physiology to determine their level of prior knowledge in general physiology. Of the 273 subjects, 31 were identified as having significant knowledge in physiology by scoring above 59% on the physiology pretest. They participated in the study

but all their data was eliminated from the final data pool. Additionally, two other subjects' data were randomly eliminated from the study to provide an equal number of subjects in each cell of the analysis of variance. Data was calculated using a total of 240 subjects, with exactly 40 subjects in each of the six cells of the analysis of variance.

Subjects were randomly distributed to the instructional treatments of visualized mediated instruction, and verbalized mediated instruction. There were 120 subjects in each of the two instructional treatment groups from which data was collected. From within each instructional treatment group, subjects were randomly distributed to each of the cueing measures, making up the testing conditions of free recall, visually cued-recall, verbally cued-recall.

Instructional treatments and testing conditions were administered to each cell in the experimental design separately. There were six groups of subjects, making up the six cells of the experimental design. The six cells were:

1) VISU instruction + Free recall,
2) VISU instruction + Visually cued-recall,
3) VISU instruction + Verbally cued-recall,
4) VERB instruction + Free recall,
5) VERB instruction + Visually cued-recall,
6) VERB instruction + Verbally cued-recall.

The six sessions of instructional treatments and testing conditions, were administered during a six hour block of time on one day. Each session started on the hour, subjects were given 45 minutes to view the instructional treatment and take their particular test. Subjects were told prior to the instructional treatment that they would see a slide-tape instructional program on the human heart. They were told that the slide-tape program represented a typical audiovisual program used to complement a class session. They were also told to try and remember basic facts from the slide-tape instructional setting. Finally, subjects were advised to interact with the instructional program in the same way they would with an audiovisual program presented during a class session.

Immediately after the slide-tape program about the heart, subjects were given their respective testing condition. They were given instructions on how to respond to their particular test, contingent upon their type of testing condition. After the subjects completed their test, they were given instructions not to tell their friends what the slide-tape program was about and what their test was like. They were then told that the experiment investigated memory skills, and that prior knowledge about the instruction and the testing, would give their friends an advantage and contaminate the data. The same procedures and instructions were carried out in all six sessions.

Results and Discussions

The raw data was analyzed using a 2x3 analysis of variance, yielding the following resulting analysis of variance summary table (Table 1).

BETWEEN SUBJECTS				
Source	Mean Squares	Df	F-ratio	Probability
Instruction (A)	484.504	1	41.030	.0001
Cue Measure (B)	734.629	2	62.211	.0001
(A) X (B)	240.754	2	20.388	.0001
Error	11.809	234		

Table 1: Resulting Analysis of Variance Summary Table

Statistically significant results occurred in the instructional variable and in the cueing measure variable. Additionally, a statistically significant interaction occurred between the instructional variable and the cueing measure variable.

The significant results on the instructional variable, [F(1,234,df) = 41.030, p = .0001] indicated that the visualized mediated instruction mean ($\bar{X}$ = 13.175) was superior to the verbalized mediated instruction mean ($\bar{X}$ = 10.333). This finding is generally consistent with prior research (Dwyer, 1978) which contends that when visualization is properly designed and integrated into an instructional sequence, increases in student performance are likely to occur.

Significant results on the cueing measure variable [F(2,234,df) = 62.211, p = .0001] yielded statistical difference between the types of cueing measures. A Tukey test set at (.01) alpha indicated that the verbally cued-recall measure ($\bar{X}$ = 15.24) differed significantly from the free recall measure ($\bar{X}$ = 9.73), and the visually cued-recall measure ($\bar{X}$ = 10.30). In this analysis the free recall measure ($\bar{X}$ = 9.73) did not differ from the visually cued-recall measure ($\bar{X}$ = 10.30). At first glance the lack of significant differences between the free recall and the visually cued-recall measures may appear surprising, since a cued-recall measure should aid memory. However, note that a significant interaction occurred. This interaction affected the visually cued-recall overall mean score. So when the visually cued-recall mean score was averaged across the VISU and VERB instructional variable, any mathematical differences between free recall and visually cued-recall were cancelled. However, looking at Table 2, it can be seen that statistically significant differences occurred between the free recall mean ($\bar{X}$ = 10.55) and the visually cued-recall mean ($\bar{X}$ = 13.68), at the VISU instructional variable level, (Tukey test at .01 significance level). Additionally, no statistically significant differences occurred between the visually cued-recall cell and the verbally cued-recall cell at the .01 level of significance using a Tukey test. This result can be interpreted to indicate that cued-recall aids learning over free recall.

However, the encoding specificity theory would have predicted that given the VISU instructional condition, the verbally cued-recall test should have been significantly lower than visually cued-recall testing, not statistically equal. This can be explained by the fact that during VISU instruction the subject perceived a visual illustration and a verbal label. From this learning condition it can be assumed that a dual code, visual and verbal, must have then been stored since both visual cues and verbal cues allowed effective recall. In a hypothetical sense this supports the encoding specificity theory, since both visual and verbal cues related to the assumed to be stored visual and verbal encoding contexts. It is likely that a complete cross-over interaction could occur by eliminating the verbal labels from the slides in the VISU instructional condition. If this were done, subjects could acquire the target information, the part and phase names, from the audio portion of the slide-tape instructional program.

The analysis indicated a significant interaction existed between the instructional variable and the cueing measure variable [F,(2,234,df) = 20.388, p = .0001]. A Tukey test set at .01 alpha was used to indicate the source of the interaction. The individual cell means appear in Table 2 and the resulting disordinal interaction is illustrated in Figure 1.

	Free Recall	Visually Cued-Recall	Verbally Cued-Recall
Visualized Mediated Instruction	10.55	13.68	15.3
Verbalized Mediated Instruction	8.9	6.93	15.18

Table 2: Individual Cell Means.

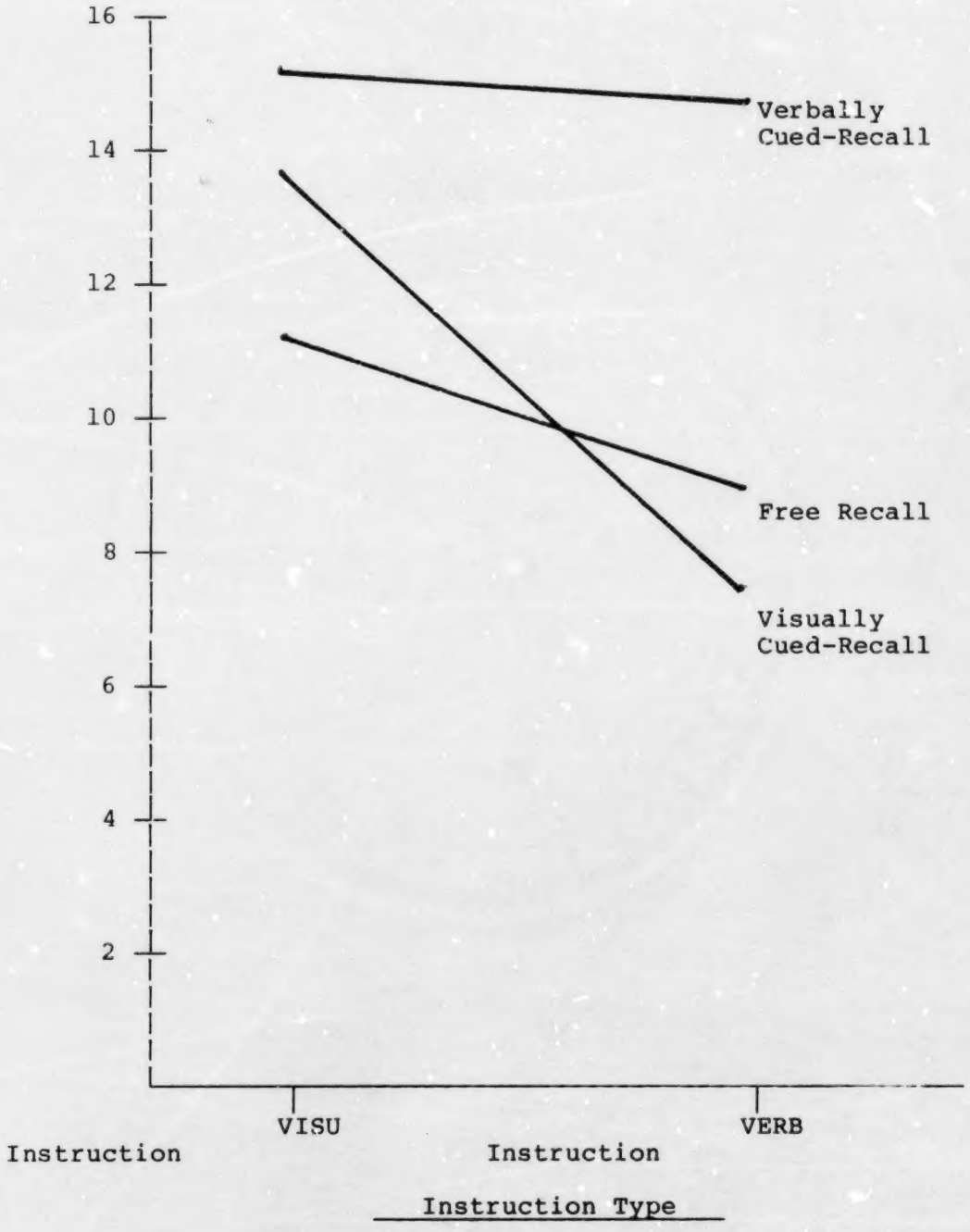

Figure 1: Disordinal interaction.

Looking at the cell means the Tukey test (alpha .01) indicated that the free recall means did not differ significantly at each of the two levels of the instructional variable, VISU and VERB. Similarly, the verbally cued-recall means did not differ significantly at each of the levels of the instructional variable. The source of the interaction was found to be with the visually cued-recall measure. As can be seen in Table 2, the visually cued-recall means differed significantly across the VISU and VERB instructional variable levels. The visually cued-recall measure was not effective for subjects receiving verbalized instruction. However, for subjects receiving visualized instruction the visually cued-recall measure was effective.

The resulting interaction finds support for the encoding specificity hypothesis, indicating a significant relationship between encoding, the memory trace, and the external retrieval cue. Both the VISU and VERB instructional conditions provided subjects with the names of the parts of the heart and the heart phase names. However, the two instructional conditions provided this essential to-be-learned information in a completely different encoding pattern. The VISU instructional condition provided subjects with the heart part and phase names in a visual context allowing storage of a visual and verbal memory trace. The VERB condition provided the part and phase information in a verbal context allowing storage of a verbal trace only. The external retrieval cue of visually cued-recall was compatible

with the visual memory plus verbal memory trace assumed to be stored as a result of the VISU instructional condition, but incompatible with the verbal only memory trace given in the VERB instructional condition. Even though both instructional presentations allowed the subjects to store the relevant to-be-learned information, they could not recall the correct information if incompatability existed between external retrieval cues in the test and information stored in the cognitive structure.

In the case of the visually cued-recall test for learners receiving verbal instruction, the resulting student performance was found not to be a function of what intellectual skills were learned from the instruction, but rather a function of the compatibility between the external retrieval cue and the stored memory trace. Even though the learner had acquired the intellectual skill of factual learning, the form of the testing condition caused the difference in performance, not the actual learned intellectual ability. The practical implications of this result relate directly to the development of instruction and testing conditions existing in the typical learning environment. If visual information is presented in the instruction, or is a critical component of instruction, visual cues should be provided for in the testing condition. For example if the learner receives a demonstration of an engineering laboratory experiment using an apparatus to be set up and correctly employed, the testing situation should not be completely verbal. In this

example the learner may have acquired the psychomotor and intellectual skill but the correct cues to allow performance may not be on the test. In training situations equipment operations and specific procedures are often taught via visualized instruction, but tests tend to be mostly verbal. It is likely that the learner may have acquired the skill but cannot perform satisfactorily because of the incompatibility between the learned information and retrieval cues provided on the test. Traditional verbal tests may be appropriate for verbal only instructional methods but if visuals are a significant part of the instruction and the learned skill, there should be visual cues on the test. These visual cues should relate directly to what is assumed to be stored in the learner's cognitive structure and be congruent in format. Presently, in most classroom testing situations, there exists a mismatch between the encoding context of instructional information and cues provided externally during testing. It is likely that in such a situation the intellectual skills may have been acquired, but performance failure may occur as a function of the extenal cue and memory trace mismatch.

The results of this study indicate that there is a significant relationship existing among encoding, the stored memory trace, and retrieval cues. Furthermore this significant relationship applies to the classroom teaching-learning-testing environment, since within the context of a classroom learning situation the encoding specificity hypothesis was able to be supported. This relationship has significant implications not

only for the development of instruction and testing, but for subsequent research endeavors in the areas of visual learning and the improvement of instruction and evaluation procedures. Future applied research in the area of encoding specificity might find it fruitful to consider the relationship that exists among encoding, memory trace, and external retrieval cues when content presentation and evaluation strategies are systematically varied, and where student intellectual performance at different learning levels is considered as the dependent variable.

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